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THE SPIRIT OF INVESTIGATION IN MEDICINE[1]

THE first Greek poet of whose personality we are certain, Arctinus of Lesbos (B.C. 770), sharply differentiated medicine and surgery, and held medicine responsible for the advancement of medical science. He relates how Esculapius "endowed one of his sons with nobler gifts than the other; for while to the one, Machaon, he gave skilled hands to draw out darts, make incisions and heal sores and wounds, he placed in the heart of the other, Podilarius, all cunning to find out things invisible and cure that which healed not." How can we, disciples of Podilarius, best proceed in this day and generation to "find out things invisible and cure that which heals not"?

The problem is as old as medicine itself The story of medical investigation unfolds itself in the history of medicine. Progress comes through ideas. Great investigators have appeared from time to time in medicine. They have contributed new ideas, in the elaboration of which they recorded new observations, recognized new facts, established laws, advanced the art of practise, and thus developed the science of medicine. As time passed the so-called underlying or fundamental sciences evolved, and in turn made fresh opportunities for the medical investigator, but they have taken a large proportion of medical investigators from the field of active practise. Some are still left who are attempting to "find out things invisible" and to solve the ever-present problems of treatment of the sick.

Recently, to further such ends, a national Society for Clinical Investigation was created (1909). According to the constitution the objects of this society are "the cultivation

[1] From The Mayo Foundation, Rochester, Minnesota. President's address before The American Society for Clinical Investigation. May 9, 1921.

of clinical research by the methods of the natural sciences, the unification of science and the practise of medicine, the encouragement of scientific investigation by the practitioners, and the diffusion of a scientific spirit among its members." Broadly speaking, these simmer down to the better care of the sick, the broadening of the bounds of medicine, and the development of the physician himself.

To the public generally, medical investigation makes no great appeal. The research worker is commonly regarded as impractical. Yet the routine practise of to-day is based on the investigation of yesterday. Wassermann tests, renal functional tests, and spinal fluid findings constitute substantial phases of the medical practise of to-day. Yet, we did not have them fifteen years ago. The public and many physicians fail to appreciate that practise is based on investigation, and that clinical investigation means better care of the sick, greater public health, and happier communities.

Investigation is complex. It demands certain mental attributes. The most essential is a veritable lust for truth. This has to be supported by skill in experimentation, accuracy in observation and record, correct interpretation of findings, and due appreciation of their significance. The lust for truth must result in active search which recognizes no sacrifice. Skill in experimentation involves insight and ability in the selection and the carrying out of well-controlled experiments. Accuracy in observation implies capacity to see, a knowledge of the subject, and an appreciation of the phenomena observed. Accuracy of record demands precise and prompt notations, made preferably during the course of experimentation, for, as a rule, observations made to-day and recorded tomorrow are lost to science. Correct interpretations of findings and due appreciation of their significance demand a well-trained mind, critical judgment, and a familiarity with the subject in relation to contemporary science.

This may be stated in a somewhat different way. Investigation consists of four fundamental factors: (1) the clear conception of the problem, that is, a definite "Fragestellung"; (2) the selection or development of methods capable of solving the problem; (3) ability to recognize relationships, to orient the problem to existing facts; and (4) accurate measurements and records.

The spirit of investigation is a living force, born within or rendered kinetic by contact from without, which, when first awakened, is usually feeble and requires cultivation, but when fully developed directs action and controls destiny. It is difficult to define, to understand, to acquire, to cultivate, and to communicate.

The cultivation and the diffusion of the spirit are our problems. Once the investigator is imbued with the spirit, investigations will proceed and bring results. But in diffusing, the spirit must be communicated so that it may be acquired by another. Consequently we must consider its acquisition as well as its cultivation and diffusion.

Acquisition of the Spirit of Investigation.—The statements of Hippocrates relative to the attributes desirable in the student for instruction in medicine apply equally well to the prospective investigator. Hippocrates says:

> Whoever is to acquire a competent knowledge of medicine ought to be possessed of the following advantages: a natural disposition, instruction, a favorable position for the study, early tuition, love of labor, leisure. First of all, a natural talent is required, for when nature opposes everything else is vain, but when nature leads the way to what is most excellent, instruction in the art takes place, which the student must try to appropriate to himself by reflection, becoming an early pupil in a place well adapted for instruction. He must also bring to the task a love of labor and perseverance, so that instruction taking root may bring forth proper and abundant fruit.
>
> Instruction in medicine is like the culture of the production of the earth, for our natvral disposition is, as it were, the soil; the tenets of our teacher are, as it were, the seed; instruction in youth is like the planting of the seed in the ground at the proper season; the place where the instruction is communicated is like the food imparted to vegetables by the atmosphere; diligent study is like the cultivation of the fields; and it is time

which imparts strength to all things and brings them to maturity.

But we need not concern ourselves unduly about the extent and character of the soil. Every year brings into medicine thousands of young men—"good ground" capable of bringing forth fruit, "some thirty, some sixty and some an hundred fold." To be sure, we must participate in the cultivation of the soil, but to the planting of the seed in the ground at the proper season we must first direct our efforts.

The present season is unusually favorable. Formerly much of the sowing and early cultivation among Americans was done abroad. Since this is no longer possible, the responsibility is clearly ours. Never in the history of American medicine has the responsibility been heavier, the opportunity greater. Seed time in medical life rarely lasts more than ten years. It is represented by years in the medical school and those immediately following graduation. In the undergraduate years, intensive cultivation, as a rule, preempts the field and permits sowing and cultivation, but rarely harvesting. Unless fruit is brought forth within five years of graduation it is rarely forthcoming. In this crucial period of growth there are in this country at the present time probably a thousand young men properly seeded, but in need of cultivation. In this period environment is all important and includes subsidiary factors necessary to production, such as time, space, facilities for work, inspiration, guidance, criticism, advice, and access to literature. Growth at this period is, as a rule, not sufficiently advanced to permit the investigator to control these factors personally. The responsibility rests, therefore, upon the sowers.

Some of these factors are supplied by the creation of the so-called "atmosphere." Our greatest need in medicine is institutions with atmosphere. All of us who have worked in certain medical centers have recognized the existence of atmosphere and have felt its influence. It results from the reciprocal stimulation of many capable workers in diversified fields. It constitutes, as it were, a high tension center capable of furnishing inspiration to many.

The Cultivation of the Spirit—Work.—Osler's masterword in medicine is also the masterword in investigation. Every member of this society should possess the spirit, and is pledged to its diffusion. This means always more work. American medicine looks to the members of this organization for leadership in clinical investigation. It is self-evident that real leadership can not be exercised with work that is finished. Only he who continues to work continues to lead.

Great efforts have been put forth in this country during the last decade to do away with the old system whereby the energies of so many clinical investigators of merit are diverted into other fields. A man capable of high-grade investigation should not be converted into a routine teacher, administrator, or practitioner solely. For it can not be too strongly emphasized that capable investigators are more rare than good administrators, and a first class teacher must be an investigator.

The medical way is but a succession of decisions. The successful investigator faces continuously the situation described by William James. In one of his letters he says,

> I stand at the place where the road forks. One branch leads to material comfort, the flesh pots, but it seems a kind of selling of one's soul; the other to mental dignity and independance, combined, however, with physical penury. On one side is science, on the other business.

The further the medical road is successfully travelled, the more enticing are the by-paths leading from investigation, and they need not all be paved with gold. The sign posts carry such inscriptions as "deanship," "professor," "director," or "chief." These signs on the medical way are dangerous, and ofttimes deceive the very elect, especially if the elect be hampered with physical penury or blessed with a large family. Despite position failure to continue to investigate leads to loss of those attributes necessary for leadership. Neither position nor worldly possessions should insure leadership in medicine. Work is the masterword, work in the class-room, laboratory,

ward, and office. Investigation can not be done solely from the office desk nor from over the tea cups.

Science rests on investigation, and investigation is measuring. With the modicum of science at his disposal, the busy practitioner is not equipped mentally, nor has he the time nor the technical facilities necessary to deal with the more complex problems of disease. The investigator must needs keep pace with contemporary science, in itself a big undertaking, and must apply it to medical problems as opportunity arises or can be created. As Galileo was engaged in the creation of the sciences of physics and mathematics, Sanctorius through his assistance was engaged in applying the thermometer and balance, that is, the new instruments of science, to the problems of physiology. This is as it should be. In these days physiologists and physiologic chemists at times intervene, but some times as liaison officers only, between the clinician and pure scientists. The field in medicine for the pure scientist is still great, despite the splendid contributions to medicine which constantly pour forth from the laboratory workers in the fundamental branches of medicine. Closer and more direct points of contact are desirable, more direct intercourse, in order that the problem, as seen by the physician, may be placed first-hand and in its true light before the pure scientists.

Diffusion of the Spirit.—There are at present in this country a relatively large number of young men capable of developing into investigators. This society has approximately 150 members, all of whom are obligated to the diffusion of its principles. As a society, to my mind, we are not even approaching the possibilities in diffusing the love of investigation among the younger men.

Membership in this society entails responsibilities. Eligibility for membership is simple. Any practising physician in the United States who has accomplished a meritorious, original investigation and who enjoys an unimpeachable standing in the profession is eligible. But once a member, the responsibility of a leader is assumed, since one of the obligations imposed upon its members by this society is to be "active in the diffusion of the principles of this society."

This is a national organization comprizing members from every part of the country. It meets once a year and presents and listens to twenty-five papers. Many younger men are scattered throughout the country who have no access except through abstracts to the proceedings of this society. The founder of this society recognized this truth. He met the situation, however, in his own locality by founding the Society of Experimental Biology and Medicine in New York City with a constitution embodying principles identical with ours. The local society functions locally and attempts to accomplish locally what we are attempting nationally. It meets frequently, whereas we meet annually. It reaches those who need its influence most.

As president of this society I wish to suggest that we consider and adopt some plan whereby we can be more effective in the cultivation of the spirit of investigation. It might be wise to follow the example of Dr. Meltzer and create subsidiary, local societies of clinical investigation in various medical centers throughout the country, societies which would carry some sort of affiliation with the national society.

How could such a plan be carried out in Boston, for instance? At the present time each institution entering into consideration has, in all probability, its own society intended for the cultivation of the spirit. Without disturbing their present organization or function, it would be possible to hold joint sessions once a month in the various institutions, as the Boston Society for Clinical Investigation. Such an organization would afford each Boston member an opportunity to attend, to bring with him his young associates and to meet those of the others, and to diffuse and instil the spirit into the entire group. On a small scale such an organization would afford the beginner the same opportunities and advantages enjoyed by us through membership in this society. By holding the meetings in the various institutions, each beginner would be afforded an op-

portunity to acquaint himself with other institutions and their staffs, such advantages as some of us on a larger scale have enjoyed through membership in the Interurban Clinical Clubs. From the local programs could be selected the best material for presentation before the national society. From the local society could be selected those most fit for full membership in this organization. Thus, without necessarily increasing the number of meetings, through the organization of subsidiary, local societies, the spirit of investigation could be better cultivated among those whose need is greatest. Since the aims are identical, the advantages accruing to the members of the local organization are obvious, but whether their relation to us should be official or unofficial is for us to decide.

Dr. Meltzer, the founder of this society and the prototype of the clinical investigator, recognized very clearly the need of encouraging younger men in their investigative aspirations. We could not do greater honor to his memory than to follow his example and create local centers fostering clinical investigation.

LEONARD G. ROWNTREE

THE MAYO CLINIC

OBSERVATIONS OF THE AURORA AT THE LOWELL OBSERVATORY MAY 14, 1921

THE very brilliant auroral display which appeared on May 14 exhibited frequently the phenomenon of streamers diverging from a definite point in the heavens, and it was often possible to locate this radiant, with reference to the stars, with considerable accuracy. The resulting positions, with the times of observation, are as follows:

Mountain Time	Hour Angle	Declination
8^h 54^m	$+47^m$	$+4°.5$
8 56	+ 39	+ 3 .6
9 00	+ 39	+ 4 .4
9 01	+ 44	+ 4 .4
9 04	+ 30	+ 3 .7
9 06	+ 34	+ 3 .1
9 13	+ 39	+ 3 .7
9 16	+ 38	+ 2 .6
9 19	+ 40	+ 3 .0
9 20	+ 37	+ 2 .7
9 24	+ 31	+ 2 .2
.. ..	....	....
10 49	+ 21	+ 2 .3
10 55	+ 31	+ 2 .8
11 02	+ 26	+ 3 .8

Jupiter, Saturn and β Virginis served as comparison stars for the earlier observations and ζ Virginis for the last three. The means of the first eleven estimates and of the last three, give:

Mountain Time	Hour Angle	Declination	Altitude	Azimuth
9^h 08^m	$+38^m$	$+3°.4$	$57°.2$	S 17°.4 W.
10 55	+ 26	+ 3 .0	57 .4	S 12 .1 W.

The average deviation of a single observation from the mean is $\pm 0°.7$ in declination and $\pm 3^m.5$ in hour angle, so that the difference between the two positions appears to be real.

The mean of the two, giving the first double weight, places the radiant in altitude 57°.3, azimuth S 15°.6 W. The magnetic dip at Flagstaff is 62° and the variation 15° E. so that the radiant was very nearly on the magnetic meridian but about 5° south of the "magnetic zenith."

The aurora was not only very bright, in spite of the light of the half moon, but extended surprisingly far south. About 9 P.M. several bright patches were seen low in the south, and at 11 the whole southern sky was full of streamers and patches of light.

At 10:57 a remarkable group of short curved streamers appeared surrounding the radiant. These were but a few degrees in length, but very bright, and a distinct motion of the luminosity along the streamers was visible,—outward in all directions from the radiant, and with a curvature in a counter-clockwise direction. The motion was rapid, covering the length of the visible streamers in less than a second, and the impression was strong that what was seen was the actual motion of the particles which enter the atmosphere and cause the luminescence.

HENRY NORRIS RUSSELL

May 16, 1921

During the last twenty years I have known of bright auroral displays being observed in Arizona on only a few occasions. One of these was on June 15, 1915, another one on March 22, 1920, and a third on the 14th of the present May. The first and the third of these were observed at the Lowell Observatory, but not the second one as it came during unfavorable observing weather at Flagstaff. Of the two I observed, that of May 14 was much the more brilliant and wonderful (and this doubtless was also a finer display than that of March 22, 1920). It was recognized about 8:30 o'clock, and rapidly increased in brightness, soon displaying streamers and bright and dark cloud masses with the curtain or drapery features. These continued bright for some time and then in more or less subdued intensity during about an hour when the northern sky began again to show the arch and drapery effects rising and it was soon evident that another outburst was developing. This one then also progressed rapidly and at its height near eleven o'clock it was even more remarkable than the first.

The rays (for convergence of these see observations of Dr. Russell and Mr. Lampland given herewith) and the cloud forms were present in all parts of the sky at eleven o'clock. Some of these in the southern sky attracted my attention particularly by undergoing striking fluctuations in brightness. These would be bright for a few minutes, would then fade nearly or quite to invisibility, brighten again and fade, repeatedly, in the same position. There were a few small ordinary vapor clouds scattered low in the east and northeast and one or two in the southwest, which as reference objects brought out clearly the very different and fleeting behavior of the auroral clouds, both the luminous and the dark, which impressed me as being the remnants of the dismembered arch and draperies that spread over the whole sky. The spreading of the auroral canopy southward over the sky was most striking as it swung forward through the east and the west. The color displayed was most noticeable in the northwest where a red tone usually prevailed and was at times quite strong. A less intense red tint was sometimes very evident in the northeast. I did not see the blue tones sometimes reported for northern auroral displays. The most of the light was of the intermediate colors, silver with more or less greenish yellow, the silvery tone being noticeable for the higher streamers and the green and yellow tones increasing somewhat with the zenith distance, and particularly was the northern sky generally yellow with some green and less often some red tones.

My efforts were directed toward getting spectrographic observations of the aurora. Unfortunately no properly adjusted spectrograph was in readiness, but owing to the length of the display two slit spectrographs could be set up and three useful spectrograms secured. Two of these were with a single prism and a three and a quarter inch focus camera, and the third with a very dense prism and a 15 inch focus camera. The first of the small scale spectra on an isochromatic plate, is the stronger and shows about fifteen lines and band heads between λ 3800 and the chief aurora line at λ 5578.0. Those near λ 3914 and λ 4276 were especially strong and appeared to be the less refrangible edges of flutings (band heads)—this is probably also true of the radiation near λ 4650. The other small scale spectrum, on Ilford Panchromatic plate, shows the stronger of these lines, including the line λ 5578 and a line in the red whose wave-length according to my preliminary measures is near λ 6320.

The negative made with the higher dispersion instrument, on Ilford red plate, records only faintly the chief aurora line, measures of which give the wave-length as 5577.8. This is in satisfactory agreement with the value 5578.05, which I found some years ago for this line from higher dispersion plates exposed to the permanent auroral light of the sky. This observation is of interest in that it leaves no further doubt that the wave-length is the same, within the errors of observation, whether the auroral light is that permanently scattered over the sky or is that of a violent storm display. The red line λ 6320 had been previously observed visually but this is I be-

lieve the first time it has been photographed and the negative should furnish much the more accurate determination of its wave-length.

V. M. SLIPHER

LOWELL OBSERVATORY,
FLAGSTAFF, ARIZONA,
May 20, 1921

THE magnificent auroral display seen at the Lowell Observatory on the evening and night of May 14 was of much interest to observers in a latitude so far south on account of the great brilliancy and diversity of types of many of the formations and their widespread distribution over the sky. The auroral light was first recognized about 8:25, or a little earlier, before twilight had disappeared. The lower sky was then very brilliant in the north and particularly in the northeast, and the characteristic greenish auroral color was predominant but over parts of the active areas a suffused ruddy glow was conspicuous, especially in the northeast. Almost immediately streamers made their appearance in the north and northeast. Ten or fifteen minutes later the display developed into great activity. Long brilliant streamers were reaching up towards the zenith and beyond, and at the same time occurred in various parts of the sky, but especially in the east and west, brilliant patches, and masses of light suggesting unevenly illuminated cloud forms as when cumulus masses are lighted on one side with the great bulk of the cloud thrown into relief by the parts that are more feebly illuminated or in the shadow. One was inclined at first to attribute these massive forms, the darker parts barely perceptible against the background of the sky, as being partially due to atmospheric clouds. But their auroral origin soon became evident. The entire formation vanished when the auroral activity in that region ceased, and also, with some attention, it was possible to distinguish the few inconspicuous ordinary atmospheric clouds present. Several of the brilliant patches persisted in nearly the same position for some time, fading out and brightening up again repeatedly.

The greatest activity of the second outburst occurred between the hours of 10 and 11. Auroral formations were at that time visible in practically all parts of the sky, exhibiting simultaneously streamers, luminous masses, and bright patches, and all undergoing incessant change. Streamers from every direction were playing across the heavens, the great beams of light gradually becoming narrower on approaching the region of convergence.

The activity in the region near the convergent was at times quite remarkable. The transformations were complex and rapid, the luminous detail flaring up and fading out in almost the twinkling of an eye in some instances. About 10:46 occurred a very striking display in this area when detail formed and dissolved at an extremely rapid rate, structure appearing in momentary flashes and at one time suggesting the fragments of a partially formed crown.

The term "convergent" will be used in connection with the phenomena of the streamers, as I had frequently the impression that the streamers from different directions *did not radiate* from the region of their concurrence but in many cases took a perceptible interval in rising from the lower parts of the sky to the point in question, gradually approaching it in a series of intermittent or pulsating advances. Doubtless the apparent configuration is a matter of perspective as in the case of meteor paths. The streamers descending along the lines of force of the earth's magnetic field are for any locality nearly parallel and the vanishing point—the point where the streamers appear to meet—would be the highest altitude at which the streamers become visible. Strictly speaking, it might be more definite to use the term radiant as understood for meteors.

The writer made several estimates of the convergent of the streamers but he missed many opportunities for additional estimates as well as for observing and recording numerous other phenomena in attempting to photograph the streamers in the region of their concurrence. At this point, or small area, the streamers were much of the time comparatively faint

and never long at rest, and when momentarily a favorable formation developed the intensity fell off too rapidly to give suitable photographs for accurate determination of the convergent. At times the convergent could be readily determined when streamers from many different directions were nearly or actually concurrent and the position of this point could be located with reference to comparison stars. My own observations were as follows:

M. S. T.		H. A.		Dec.	Azimuth	Altitude
h.	m.	h.	m.	°	°	°
9	10	0	36	3.6	16.8	57.3
9	14	0	36	2.8	16.6	56.5
9	16	0	36	2.8	16.5	56.5
9	19	0	45	3.0	20.3	56.2
9	22	0	38	2.2	17.2	55.8
		0				
10	50	0	22	—0.2	9.4	54.2
10	52	0	21	+3.7	10.0	58.1
11	25	0	30	+1.9	13.5	56.0

These observations, and also Dr. Russell's, show that generally the point of convergence was near the magnetic meridian but between 5° and 6° south of the "magnetic zenith" (coordinates of the magnetic zenith for Flagstaff are: azimuth S. 15° W.; altitude 62°). If the auroral streamers follow the lines of force of the earth's magnetic field the higher parts of the streamers might be expected to show a deflection in the direction indicated but no calculations have been made to see if the magnitude of the apparent displacement might be of the order observed. What the effect of parallax may be is also a point not to be overlooked. There can be little doubt but that the point of convergence was subject to greater actual variation in azimuth than altitude. In the magnetic disturbances that accompany auroras it is possible that changes in the earth's magnetic field might be perceptible in the course of the auroral streamers.

At 10:44 a series of parallel streamers, coming into view almost directly overhead and extending east and west, were seen drifting very rapidly towards the north, with undulating and flickering motions flowing lengthwise through them. They were visible for only a moment, the detail dissolving a short distance north of the zenith, and one had the impression that the phenomena taking place were comparatively near.

Streamers of both narrow and broad (at times somewhat diffuse) types were present. As a rule a greenish tint was most prominent in both the streamers and the extensive luminous areas but a pinkish or ruddy color was also much in evidence. At various times pinkish or pale red streamers were seen, generally in the northeast or northwest. A broad pinkish streamer in the northwest appeared to be rather quiescent and remained visible much longer than any of the other streamers during the display. It was 3° or more in width, extending perpendicularly upward from the horizon about thirty degrees. About 12:35 a superb display of both pinkish and green streamers was visible for a few minutes in the northeast, extending up about 45° from the horizon, considerably inclined southward. Throughout the display streamers of greatly varying intensity playing upward from the northern horizon were visible but these were not as conspicuous as might have been expected in view of the brightness and activity of the auroral light in other parts of the sky. Occasionally these streamers were subject to marked flickering, and some movement—a slow lateral drift. Now and then dark lanes occurred between the streamers, and in one instance a very conspicuous dark rift had a leisurely motion eastward.

From the time the auroral light was first made out in the waning twilight it was strong, with greatly increased intensity during the intervals of the outbursts mentioned, until after 1 o'clock when it rapidly subsided into a feeble glow along the northern horizon. It was reported by someone stationed at a sheep camp north of the San Francisco Peaks that another outburst of streamers developed later in the night.

The auroral light must have been of great intensity as the display was a magnificent spectacle even when dimmed with the light of the moon near the first quarter.

On the day following the display two spots

of considerable size were seen on the solar surface not far from the center of the disk.

C. O. LAMPLAND

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SCIENTIFIC EVENTS

THE PRODUCTION OF FIXED NITROGEN

THE final report of the Nitrogen Products Committee of the British Ministry of Munitions, issued early in 1920, has been supplemented by a series of statistical tables relating to nitrogen fixation, now published by the Stationery Office, covering the latter part of the war and the period that has elapsed since its termination. This additional information has been compiled by Dr. J. A. Harker, formerly director of the Nitrogen Research Laboratory, for the Department of Scientific and Industrial Research.

Among other things, the statistics deal with the world's resources in nitrogen products, the Chile nitrate industry, the production of nitric acid and sulphate of ammonia, the synthetic ammonia process during the war, and the cyanamide industry. It is estimated that the world's capacity for the production of fixed nitrogen amounted last year to 1,561,000 tons, of which about 57 per cent. was attributable to natural sources, such as Chile nitrate and the by-product industry, and the remainder to artificial fixation processes.

The London *Times,* from which we take this information, says:

The most striking, and in some ways the most disquieting, feature of the statistical supplement to the Nitrogen Products Committee's report (mentioned in *The Times* of yesterday) is the great increase in the world production of fixed nitrogen, and of the fact that of the 50 plants in operation throughout the world, not one is established in this country and only two are to be found within the Empire. Canada has one arc process plant with a maximum capacity of 800 metric tons a year and a cyanamide process plant estimated to be capable of 12,000 tons. Thus, of the world's total estimated capacity for 1920 of 671,300 tons, the British Empire commands only 12,800 tons.

A fuller examination of the position reveals the conclusive predominance of Germany in this field. While Norway outdistances all rivals in the arc process, producing 30,000 tons out of a total of 38,300, Germany, taking the three processes together, produces nearly twice as much fixed nitrogen as the rest of the world. Of the 325,000 tons credited to the cyanamide process, Germany commands 120,000, while under the synthetic ammonia process she has a capacity of 300,000 tons, and the only rival is the United States, with the almost negligible figure of 8,000. Put in a sentence, Germany can produce by fixation processes 424,000 metric tons of nitrogen a year, and the rest of the world can produce only 237,000 tons, of which this country produces none.

Our one internal source of fixed nitrogen is therefore by-product works, and even there we produce only 100,000 tons against Germany's 150,000. As a net result our internal resources —that is, the resources on which we should have to rely if all colonial and foreign supplies were cut off—represent 2,240 tons of fixed nitrogen per million of population, while Germany's resources amount to 8,830 per million of her population. It is sometimes suggested that our inaction in this field may yet prove of advantage, since by waiting until experiment had demonstrated the best process, we might adopt it and then pick up our competitors. The history, however, of our loss of the synthetic dyestuff industry, which began in 1856 with Perkin's discovery of mauvine and still flourished for 20 years after, gives little support to this complacent theory.

The plain truth is that while other countries, especially Germany, have carried their experimental work well into the productive and commercial stage, we are still engaged in constructing plants and debating the merits of the processes of German, French, and other chemists. The synthetic ammonia factory at Billingham, designed to manufacture about 60,000 tons of ammonia nitrate annually for war purposes, was begun by the Ministry of Munitions early in 1918, but at the time of the Armistice was only very little advanced. This is now being redesigned by Brunner, Mond and Co., to manufacture fertilizers, and a subsidiary company is at present concentrating upon designs for an initial plant to produce 25 tons of nitrogen per day or about 6,000 to 7,000 tons annually. Cumberland Coal Power and Chemicals, Limited, have purchased the British rights in the French process by Georges Claude, and the British Cyanides Company are continuing at Birmingham their large-scale experiments on fixa-

tion of nitrogen by the barium process. The fact remains, however, that we are still in the constructional or experimental stage, while Germany far outdistances all competitors in actual production.

FORESTRY LEGISLATION

The Forest Service, United States Department of Agriculture, reports that no less than thirty-three states have now provided for some sort of forestry activities and twenty-five of these share in the federal cooperative forest protection fund, allotted to states maintaining an effective fire detection and suppression system.

Two others have applied recently for such assistance. Public backing of the movement to preserve the remaining forests from destruction by fire, and to put idle forest lands to work growing trees, is becoming widespread, and the effects of the popular demand for action is shown clearly in the state laws passed this year.

Pennsylvania, under the direction of Gifford Pinchot, the new commissioner of forestry, leads all states in forest activities. The biennial appropriation passed by the legislature and approved by the governor carried $1,870,000, an increase of $863,300 over the appropriation of 1919; $1,000,000 of the total is for fire protection. The legislature also passed an act empowering the federal government to acquire lands on the watersheds of navigable streams within the state, by purchase or condemnation, and to control and regulate such reserves.

The Minnesota legislature was more generous with the state forestry board than ever before. A total of $275,500 for general forestry work was appropriated for the next two years, of which $125,000 a year is for fire protection. The last named sum was augmented by an additional allotment of $44,000 from the state board of relief. For the equipment of a flying field $45,000 was voted. This provision was to meet the offer of the federal government to furnish the service of twelve planes if the necessary hangars and flying fields were provided. While the primary purpose of this agreement is to supply aerial mail communication, the planes will be able also to render effective service in discovering forest fires.

In California, where there has been much favorable sentiment toward forestry for many years, the legislature voted a substantial increase in appropriation for the state board of forestry, for the biennial period beginning July 1. For the prevention and suppression of fire $75,000 was appropriated; for general administration, $27,000; for a study of watershed areas, $10,000, and to establish and maintain state forest nurseries, $35,000. The legislature also voted $300,000 for the purchase of redwood timber land for park purposes along the state highway in Mendocino and Humboldt counties, the area to be administered by the state board of forestry.

THE HARVARD SCHOOL OF PUBLIC HEALTH

Plans for the organization of a School of Public Health in Harvard University, with the aid of an initial gift of $1,785,000 by the Rockefeller Foundation, are announced by the university and the officers of the Foundation. The announcement says:

> An excellent general course for the training of public health officers as well as special courses in preventive medicine, in tropical medicine and industrial hygiene have already been developed at Harvard. The work has been hampered, however, by lack of adequate funds and by uneven growth.
>
> The new school will provide opportunities for research, will unify existing courses and will offer new or extended teaching facilities in public health administration, vital statistics, immunology, bacteriology, medical zoology, physiological hygiene and communicable diseases.
>
> For the housing of the school the university hopes to secure an existing building of very suitable character immediately adjacent to the Medical School. Funds for the purchase and equipment of the building will be drawn from the gift of the Rockefeller Foundation.
>
> The cost of maintenance and development of the school will be met from endowment funds in part set aside by the university and in part contributed by the Foundation. The Foundation's immediate appropriations to the project will aggregate $1,785,000. The arrangement also provides for further gifts, if the growth of the school seems to demand it, to any amount which shall not exceed $500,000.

Though the School of Public Health at Harvard will have its headquarters in a well-equipped building of its own and have its own separate faculty and administration, it will be developed in close relation with other divisions of the university, especially the Medical School.

The administration buildings of the two schools will, it is hoped, stand side by side on the same grounds; certain heads of departments will be members of both faculties; and a number of laboratories and lecture rooms will be used in common.

The school will be able to cooperate with a large number of laboratories, hospitals and public health agencies in Boston and thus afford its students unusual opportunities for first-hand investigation and practical field experience.

In addition, the school, through cooperative relations with a number of manufacturing and commercial corporations, will be able to offer the students practical experience in industrial hygiene.

There already exists a School of Public Health conducted jointly by Harvard University and the Massachusetts Institute of Technology. Professor M. J. Rosenau, of the Harvard Medical School, is the director of this school, and the other members of the administrative board are Professor G. C. Whipple, of the Harvard Engineering School, and Professor C. E. Turner, of the Massachusetts Institute of Technology.

SCIENTIFIC NOTES AND NEWS

THE British chemists who have been meeting at Montreal and Toronto will be welcomed at Niagara Falls by Governor Miller on Monday, September 5. The reception committee of chemists consists of Mr. S. R. Church, chairman of the American Section of the Society of Chemical Industry; Dr. Edgar F. Smith, president of the American Chemical Society; Dr. David Wesson, president of the American Institute of Chemical Engineers; Dr. Acheson Smith, president of the Electrochemical Society; and Drs. Charles F. Chandler, Ira Remsen, M. T. Bogert and William H. Nichols, past presidents of the Society of Chemical Industry. As has already been noted in SCIENCE, the opening meeting of the American Chemical Society in New York City will be at Columbia University at ten o'clock on the morning of September 7.

AT the recent second International Conference of Pure and Applied Chemistry held at Brussels, Professor Charles Moureau, of Paris, presided. The vice-president representing the United States was Dr. F. G. Cottrell, recently chief of the Bureau of Mines and chairman of the Division of Chemistry of the National Research Council.

GEORGE OTIS SMITH, director of the United States Geological Survey, has returned to Washington from London, where he went to serve as a member of the organization committee of the International Geological Congress, the next meeting of which is being arranged for August, 1922, at Brussels.

MR. C. J. WEST has left the position of director of the Information Department of Arthur D. Little, Inc., Cambridge, Mass., to become managing editor of the "Tables of Physical and Chemical Constants," which is being published by the National Research Council, in cooperation with the American Chemical Society.

MR. GEORGE A. OLSON has resigned as chemist of the Washington Agricultural Experiment Station and state chemist of the State of Washington, in order to accept the position as director of agricultural research and agricultural adviser for the Gypsum Industries Association, Chicago, Ill., which position was formerly held by Dr. William Crocker, who recently resigned to become the director of the Thompson Institute for Plant Research at Yonkers, N. Y.

FRANK C. MORRISON, assistant director of the agricultural experiment station of the University of Wisconsin, has been appointed a member of the committee on Animal Nutrition of the National Research Council.

B. D. PORRITT has been appointed director of research by the Research Association of British Rubber and Tyre Manufacturers.

FOLLOWING the recent transfer of the Port Erin Biological Station to Liverpool University (department of oceanography), Mr. Herbert C. Chadwick, who has been curator under

the Liverpool Marine Biology Committee for the last twenty-four years, has resigned, but remains on the staff of the institution as research assistant. Mr. J. Ronald Bruce has been appointed naturalist-in-charge.

We learn from *Nature* that at the annual general meeting of the Röntgen Society the following officers and council were elected: *President,* Professor J. W. Nicholson; *Vice-Presidents,* Dr. G. H. Rodman, Sir Ernest Rutherford, and Sir William Bragg; *Hon. Treasurer,* Mr. G. Pearce; *Hon. Secretaries,* Dr. E. A. Owen and Dr. J. R. Reynolds; *Hon. Editor,* Dr. G. W. C. Kaye; *Council,* C. Andrews, Dr. H. Black, A. E. Dean, Major Kenelm Edgcumbe, N. S. Finzi, Dr. F. L. Hopwood, Dr. F. H. Johnson, Dr. R. Morton, C. E. S. Phillips, Professor A. W. Porter, Professor A. O. Rankine, and Sir Archibald D. Reid.

The following physicians have been elected members of the Brazilian Congress: Professors C. Fraga and P. Mendes, from Bahia, and Professors A. Sodré, A. Austregesilo and Dr. M. de Medeiros from Rio de Janeiro.

Professor William H. Hobbs, of the University of Michigan, is now in Japan to make an investigation of the coral islands.

According to *Terrestrial Magnetism,* the New Zealand Government has made arrangements for the continuation of the magnetic and seismic work of the Samoa Observatory at Apia. Dr. Angenheister, in charge from 1914 to 1921, has returned to Göttingen, Germany. The New Zealand government did not have available funds for the observational work in atmospheric electricity and meteorology. Accordingly, Dr. H. M. W. Edmonds, of the Department of Terrestrial Magnetism of the Carnegie Institution, was stationed at Apia for the continuation, during the year, of the work and for the purpose of taking charge of the department's secular-variation work in the Pacific Ocean. He arrived at Apia the latter part of June. Mr. C. J. Westland, of New Zealand, succeeds Dr. Angenheister in the charge of the Observatory.

Professor Frank H. Bigelow retired from the directorship of the Observatorio Solar y Magnetico, Pilar, Argentina, on June 30, and will reside for the present in Southern France. He will prepare for publication a series of papers describing his researches on atmospheric physics.

Governor Baxter, of Maine, has received an undated letter from Captain Donald B. MacMillan, the Arctic explorer, now on an expedition to Baffin Land, in which he writes: "I have taken on the last provisions and fresh water and am now awaiting weather to clear before proceeding northward to Hopedale, the first Eskimo settlement. The *Bowdoin* is proving to be a wonderful sea boat. Had her going the other day with sea rail under and fore rigging cutting every wave."

The *Journal* of the American Medical Association states that as Ramón y Cajal will soon retire as professor of histology in the School of Medicine of Madrid, Dr. Van Baubergen introduced a bill providing that Cajal should be appointed honorary dean of all Spanish medical schools, and that he should be granted an annual pension of 25,000 pesetas (about $3,200). The minister of public education, while endorsing its first paragraph, held that the pension could not be granted, as it would violate the budget law. Cajal tried to stop subsequent action in favor of the pension, publishing a letter in which he said, "The legend of the poverty-stricken and neglected researcher has no application in my case." Cajal asked in his letter that, rather than granting him a pension he does not need, they should increase the funds for the Cajal School. The government accepted the suggestion and increased by 50,000 pesetas (about $6,500) the annual appropriation for the school.

The *Journal of Industrial and Engineering Chemistry* states that the Fixed Nitrogen Research Laboratory, located at American University, Washington, has been transferred from the War Department to the Department of Agriculture. Dr. R. C. Tolman, director, will remain in charge, and the entire personnel of 110 to 120, including 50 of the best trained experts in the world on nitrogen, is transferred. Most of the work of the laboratory

has been done on the cyanamide process that is used in the Muscle Shoals plant, but the Haber and arc processes have also been studied. The laboratory will still consider nitrogen production from a military viewpoint, but it will do intensive work on problems of nitrogen supply for agricultural purposes. The laboratory and the Bureau of Plant Industry of the Department of Agriculture have in the past year made extensive field tests on various fertilizers produced at the Alabama plants, and it is planned to continue and enlarge these tests. Dr. R. O. E. Davis, in charge of the soil physical investigation of the Bureau of Soils, has been cooperating in these tests.

The American Astronomical Society held its annual meeting at the Van Vleck Observatory, Middletown, Conn., from August 30 to September 1. The following observatories, colleges and institutions were represented: United States Naval Observatory, Lick Observatory, Mt. Wilson Observatory, Allegheny Observatory, Dominion Observatory (Canada), Dudley Observatory, Harvard, Yale, University of Illinois, Ohio State, Princeton, Massachusetts Institute of Technology, Swarthmore, Syracuse, Dartmouth, New York University, Brown, Amherst, Wesleyan, Vassar, Smith, Wellesley, Mount Holyoke, Eastman Kodak Company, Elgin Watch Company, Warner and Swasey Co., Alvan Clark Company and American Optical Company. The program for the meeting contained thirty-eight papers based upon observations with the spectroscope, seven papers dealt with stellar parallaxes or the distances of the stars and their distribution in space, and four papers were on the nebulæ.

The British expedition which is aiming at the conquest of Mount Everest in the Himalayas, the world's highest peak, has completed its explorations to the north and west of the mountain without discovering a practical route to the summit, it is announced in a Reuter dispatch from Simla. Some hope is still entertained, however, that a route may be gained on the northeast flank of the great mountain, and when the monsoon abates another effort will be made. Meanwhile the headquarters of the expedition have been moved toward Kharta, upon which point the further effort will be based. The present expedition has surveyed about 10,000 square miles of territory on and adjacent to Mount Everest.

According to the *Journal of Industrial and Engineering Chemistry,* the first conference of the complete Pharmacopeial Committee of Revision was held July 1 and 2, 1921, at Philadelphia, Pa. The first day was devoted to subcommittee conferences, and at the close of the day all subcommittees reported their current problems settled or decided as far as possible. The following day was devoted to a meeting of the General Committee. A committee was appointed to take up the recommendation of the Pharmacopeial Convention that a conference on international standards be called before the completion of the Tenth Revision of the U. S. P. An announcement was made of the authorization by the Board of Trustees of the use of the U. S. P. IX. text for translation into Chinese. It is expected that this will be accepted by Chinese government officials and become the Pharmacopeia of China, First Edition. It was also announced that individual work on pharmacopeial problems could by special permission be released for publication. A conference was held with the Prohibition Commissioner in regard to the proposed cooperation between the department and the Committee of Revision on all questions in which pharmacopeial alcoholic preparations are involved.

A new forest experiment station, the first in eastern states, has been established at Asheville, N. C., by the forest service of the United States Department of Agriculture. Steady depletion of the southern Appalachian timber supply has been responsible for the location of this station in the east; and the object of the work to be conducted will be to secure the information needed by foresters to determine the best methods of handling forest lands in the southern mountains.

The provisional figures of births registered in England and Wales during the first quarter of 1921 show a decline of over 61,000 from

the record of the corresponding period of last year. Compared with the first quarter of 1914, however, the drop in numbers is under 8,000. Excluding the war years, the births are the fewest recorded in the first quarter of any year since 1872. The deaths registered also show a decline in numbers from the very low record of 1920, and are, indeed, the smallest in number registered in the first quarter of any year since 1868. The natural increase by excess of births over deaths was over 80,000, as compared with 133,000 in the March quarter of 1920 and 73,000 in 1914. The infant mortality was 101 per 1,000 births.

We learn from the *Journal* of the Washington Academy of Sciences that the purchase of additional land near the Connecticut Avenue entrance to the National Zoological Park, provided for in the Sundry Civil Bill for 1921, has been completed. The addition to the Park is about six acres, making the total area about 175 acres.

We learn from *Nature* that the governor-general of New Zealand, Lord Jellicoe, has formally opened the Cawthron Institute in Nelson, South Island. The institution was founded under the terms of the late Thomas Cawthron to provide a place for teaching and carrying out scientific research relating to the industries of Nelson and of the Dominion. Lord Jellicoe paid eloquent tribute to the great public generosity of the late Mr. Cawthron, and then spoke of the importance of scientific research. For an agricultural community to achieve success the agriculturists must cooperate with men of science. The work undertaken in the new institute will deal largely with problems of agriculture, fruit-growing, etc., and should therefore exert great influence on the prosperity of the whole of the Dominion. The Bishop of Nelson, who is chairman of the trustees, also addressed the gathering, and made particular mention of the library of scientific books belonging to the institute, which it was hoped, when completed, would be the best in Australasia. Professor Easterfield, director of the Cawthron Institute, gave a brief outline of the many lines of research now occupying the attention of the staff; soil surveys, experiments with fertilizers and cover-crops, fire-blight, the deterioration of trout, fruit pests, and the utilization of flax-waste were among the problems mentioned.

At a recent meeting of the Royal Geographical Society Dr. Knud Rasmussen explained the plans for his expedition to gather materials for an archeological and ethnographical survey. The expedition, which consists of Dr. Rasmussen, three other Danish scientific men and six Esquimaux, will leave the settlement of Holstemborg, in Greenland, for Hudson Bay at the end of August. The area to be explored is the central part of the archipelago, between Greenland and North America, comprising Ellesmereland, North Devon, North Somerset, Baffin Land, Borthia Felix, the Melville Peninsula and the Barren Grounds.

According to the daily press, a trading expedition to Siberia *via* the Kara Sea is on the point of leaving Europe. Two cargo boats from Liverpool, two from Hamburg, and one from Göteborg are to meet at the Russian port of Murmansk, where they will be rejoined by the ice-breaker *Alexandria* from Leith. The expedition is carrying about 11,000 tons cargo, most of which is to enter Siberia *via* the Yenesei River. The expedition is being organized by the All-Russian Cooperative Society, Limited, London.

UNIVERSITY AND EDUCATIONAL NEWS

Mr. H. H. Wills some time since presented the University of Bristol with the sum of 200,000*l.* for the provision of a new physics laboratory, and a contract for the erection of a building has now been signed. It is estimated that the work will absorb the whole of the original gift, together with interest on the fund, amounting to 21,000*l.* The building will be named "The Henry Herbert Wills Physical Laboratory."

The board of curators of the state university of Missouri has taken a definite stand

in favor of establishing a four year course in medicine at the university. The board will prepare a bill for presentation at the next session of the legislature in 1923 to authorize and appropriate money for the establishment of a state hospital at Columbia to be operated in conjunction with the medical school.

DR. H. J. WEBBER has been appointed professor of citriculture in the University of California and director of the Citrus Experiment Station at Riverside, the position he held before he accepted an industrial position at Hartsville, South Carolina.

PROFESSOR A. V. MILLER, associate professor of drawing and descriptive geometry, has been apppointed assistant dean of the college of engineering of the University of Wisconsin, to take the place of Professor J. D. Phillips, who is now acting business manager during the year's leave of absence of H. J. Thorkelson.

DR. JOHN SUNDWALL, professor of hygiene and public health at the University of Minnesota, has been made director of hygiene and public health in the newly established department of physical education.

IN the Medical School, Boston, Dr. Fred Wilbur Thyng has been promoted to be professor of anatomy, and Dr. Jesse Leroy Conel has been appointed assistant professor.

PROFESSOR H. C. PLUMMER has been appointed professor of mathematics at the Ordnance College, Woolwich, England.

DISCUSSION AND CORRESPONDENCE

AN IMPORTANT BUT UNNAMED RADIOACTIVE QUANTITY

THE problems that are met in the quantitative study of radioactive materials and processes fall naturally into two classes. One class includes the strictly chemical problems; the other, the problems that are primarily concerned with radioactive phenomena, such as the rate of emission of energy and the rate of production of alpha particles. In problems belonging to the first class we are concerned with the total amount of material present; but in problems of the second class we are directly concerned with only the relatively small fraction (λN) of the atoms present that take part in the phenomenon studied; we are only incidentally interested in the atoms that have remained untransformed.

In such problems, comparable amounts of different radio-elements are such as correspond to the same value of λN. There should be a name by which to denote the amount of any radio-element, irrespective of family, that is thus comparable to a gram of radium. If, tentatively, we use the letter r to denote this quantity, then an r of any material may be defined as that amount of the material that will produce transformed atoms at the same rate as transformed atoms are produced by one gram of radium. This quantity plays in radioactivity a part that is analogous to that played by the gram-molecule in physical chemistry, and the adoption of some name for it will facilitate the recording, discussion, and presentation of observations and phenomena.

Thus arises the question whether the term "curie," which denotes an r of radium emanation, shall be redefined so as to cover the entire field embraced by our definition of the quantity r, or whether a new name shall be added to the nomenclature of the science. This question was submitted by the Bureau of Standards to a number of chemists and physicists; the majority of those who replied favored a redefinition of the "curie."

The advantages to be secured by adopting a name for the quantity here denoted by r are considered in greater detail in an article that will appear in an early issue of the *Journal* of the Washington Academy of Sciences.

N. ERNEST DORSEY

BUREAU OF STANDARDS,
WASHINGTON, D. C.,
July 30, 1921

THE VALUE OF TILTH IN AGRICULTURE

TO THE EDITOR OF SCIENCE: If the surface of the earth be broken up to a moderate depth, the growth of plants will be marvelously increased, as has been known from time immemorial.

A scientific explanation of this fact is sug-

gested by Mr. Jerome Alexander in SCIENCE, July 22, page 74, to the effect that the evaporating surface is increased by the comminution of the soil, with the resulting increase of evaporation of the soil water. This in turn results in a greater upward flow of the soil water from below, bringing with it a greater store of plant food than would normally be transported from the depths of the soil. This induced upward movement of the soil water is thought by the author of the note in question to account also for "the curious fact well known to farmers, that in dry weather, cultivation will to a considerable extent furnish moisture to the growing crops."

The value of cultivation (aside from the killing of weeds) is unquestionably the result of a number of diverse factors, the bare enumeration of which would transcend the limits of the space available in SCIENCE. So far, however, as the movements of the soil water are influenced by the comminution of the surface concerned, there are two chief results which prove of benefit to the growing crops.

By evaporation at the surface, the minerals held in solution are left behind at a locality inaccessible to the feeding roots, which can not long exist at the surface of the land. Cultivation of the surface moves this zone of concentration to the subsurface, and here the roots are able to take advantage of the greater concentrated solution of plant foods.

The well-known fact that tilth apparently increases the amount of moisture in the land is accounted for by the *exact reversal of the hypothesis suggested* by Mr. Alexander, the fact being that the comminution of the upper surface of the soil, instead of increasing the evaporation of the soil water, more or less perfectly *stops evaporation, and thus conserves the store of soil water.*

L. S. FRIERSON

GAYLE, LOUISIANA

BACTERIA IN THE AMERICAN PERMIAN

THE presence of bacteria in the closing period of the American Paleozoic has been suggested by the condition of the fractured reptilian spine, recalling an osteomyelitis, already noted.[1] At the time this first notice was written microscopic sections of the fossil spine had not been studied. Since then, I have received four transverse sections through the spine, showing in detail the nature of the sinuses which caused the tumefaction. Careful search through the sections has failed to reveal any sequestrum, such as is commonly found in modern chronic osteomyelitis, nor were bacteria found in the margins of the calcite filled sinuses. The presence of pathogenic bacteria in such a situation would be rather rare in a fossil state, since the nature of fossilization would prevent their preservation. It is doubtful too whether we could prove the pathogenicity of such bacteria save by their location.

Bacteria of the *Micrococcus* type, so common in the fossil vertebrate material studied by Renault from the Autun of France, are however abundantly preserved in the distorted osseous lacunæ. They are similar in all respects to those occurring in the fossil bone of fishes previously described[2] from the Devonian of America and Scotland. The bacteria, often seen isolated in the terminal bulb of the canaliculus-like burrows, which radiate out from the body of the lacuna, are no doubt those of decay and had nothing to do with the infection producing the osteomyelitis. There seems no doubt that bacteria of this type may be found in any fossil vertebrate material of the type which has been embedded in moist ground long enough to undergo a slight amount of decay, prior to fossilization. The only reason they have been seen so seldom in fossil vertebrate material is simply because no one has looked for them. They are there beyond any question.

The bodies which have been interpreted as bacteria, when seen isolated at a magnification of 1240 diameters, measuring from 1 to 2.5 microns, appear as semicrystalline, rounded, brownish bodies resembling minute specks of amber. The question as to whether they

1 SCIENCE, N. S., Vol. LIII., No. 1371, p. 333, Apr. 8, 1921.

2 SCIENCE, N. S., Vol. LI., No. 1305, p. 14, 1920.

are really bacteria has been satisfactorily discussed by the researches of Bernard Renault who has placed the subject of bacteriology of fossil vertebrate remains on a safe footing. Those seen in the present sections often group themselves in pairs recalling the modern *Diplococci*. I have never seen chains of these forms in vertebrate material.

The other question as to how such minute bits of protoplasm are capable of preservation over many millions of years is one of those unsolved puzzles of paleontology which we may place with that of the fossilization of the ganoid fish brains from Kansas.

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QUOTATIONS

SCIENTIFIC PAPERS

ALTHOUGH the scientific societies made a valiant effort to preserve continuity through the war, the session now closed is the first that has been nearly normal for several years. Most of the younger men were engaged on work that does not qualify for membership of learned societies, and the scientific investigations of the others, young or old, were often advisedly kept secret. Now that science has resumed its old range and almost its old output the precise utility of the weekly and fortnightly meetings of the societies, under discussion before the war, is again being considered. Clearly they have a social value, increased by the almost universal change from the evening to the late afternoon, and by the more abundant presence of ladies, as members or as guests. But what of their specific function as an aid to the advancement of knowledge? It is to be confessed that for the most part this seems slight. Distinguished investigators are not always clear expositors by word of mouth. In many cases the programme is so long that many items, and these often the more interesting, have to be "taken as read." The actual communications made are often such that it is to be doubted if more than one out of ten of the audience has the slightest idea what it is all about. Sir James Dewar, speaking at the closing meeting of the Royal Institution, possibly partly in jest, ventured the opinion that it was good for people to listen to the most recent results of science, even if they failed to understand them. This is an opinion in which we can not concur, holding, on the contrary, that if there is a state worse than ignorance it is that of the vain worshippers of scientific shibboleths. If the purpose of a meeting is to convey instruction, the exposition should be as simple and clear as that to which Sir James Dewar himself has accustomed his audiences at Albemarle-street.

But the original purpose of the meetings of the scientific societies was to discuss new results rather than to educate. In earlier days, when the range of knowledge was narrower, almost any man of science was capable of emitting a useful impromptu opinion on almost any branch of science. An approach to such a communion between lecturer and audience may still be possible in some of the smaller and more highly specialized societies. In other bodies a useful attempt is sometimes made to reach it, by grouping the papers for a meeting, or by setting a topic for discussion. But even such arrangements frequently fail of their object, because those with most right to be heard are least anxious to criticize or to approve what they have heard for the first time, whilst those who have least claim to serious attention are most ready to hazard opinions. It would be interesting, were some society to experiment with a method frequently suggested, but, so far as we know, not yet actually adopted. It is the custom for the communications made at a meeting to be printed and published subsequently, after due examination by a referee. It is worth noting that strict precautions are taken to prevent substantial alteration or correction of a manuscript, even if the discussion had shown that these would be an advantage. There is threfore no gain by the delay, and much detriment to the value and interest of the meeting. If, on the other hand a paper were published in full, and distributed in the usual way at a due interval before the meeting at

which the author was to present it, experts and those with varying degrees of knowledge could master the main points of the thesis. They would thus be prepared to join in, or to listen to, a debate which would certainly be a real contribution to the progress of knowledge.—The London *Times*.

SPECIAL ARTICLES

ON THE LAW OF SURFACE AREA IN ENERGY METABOLISM[1]

The generalization that heat production in animals is proportional to the surface of the animal body rather than the weight of the body was first hinted at by French writers before the middle of the last century. It was formulated rather definitely by Bergmann in 1848 and was first placed on a definite footing of fact almost simultaneously by Rubner in Germany and by Richet in France in 1885. This so-called law of surface area has been quite generally accepted and has contributed much to the understanding of metabolism which we now have.

Recently this law has been submitted to severe criticism by F. G. Benedict and his colleagues[2] and the conclusion has been reached that surface area is little or no better as a measure of metabolism than is body weight. The purpose of the present communication is to direct attention to some natural limitations of the law of surface area which seem to have been overlooked by these critics. Harris and Benedict have rendered a service to the science of metabolism and nutrition by calling attention to the fact that since surface is usually expressed as a quantity in which two thirds power of the weight enters as a factor it must of necessity be less variable than the weight. As a matter of fact the mathematical relationship does not stop here; for in many instances the constant employed in the formula, for example, of Meeh or of Lissauer, by which the two thirds power of the weight is multiplied, equalizes the proportions between surfaces and weights. A few illustrations will make this clear. Suppose, for example, we have two infants weighing 7 and 8 kilograms respectively. Expressing their weights in grams and their surfaces in sq. cm. by the Meeh and Lissauer formulæ, we have the proportions shown in the first line of the following table. The ratio of

TABLE I.

Relation of Body Weights and Surfaces to Each Other

Weight Gm.	Ratio	Meeh-Rubner $11.9\sqrt[3]{(w)^2}$		Lissauer $10.3\sqrt[3]{(w)^2}$	
		Surface sq. cm.	Ratio	Surface sq. cm.	Ratio
7,000		4,354		3,769	
8,000	0.88	4,760	0.91	4,120	0.91
20 kgm...		0.8768 sq. m.		0.7589 sq. m.	
21 kgm...	0.95	0.9058	0.97	0.7840	0.97
40 kgm...		1.3920 sq. m.		1.205	
41 kgm...	0.98	1.4150	0.98 +	1.225	0.98 +
4 kgm...		0.299		0.259	
40 kgm...	0.10	1.3920	0.210	1.205	0.21
3.5 kgm...		0.274		0.237	
70 kgm...	0.05	2.021	0.135	1.750	0.136

weights is .88 : 1 and of surfaces .91 : 1. Now it is obvious that if the metabolism of these two children is proportional to their weights it must of necessity also be nearly proportional to surface. With two youths weighing 40 and 41 kilos the surfaces bear to each other exactly the same ratio as the weights, whether the Meeh or Lissauer formula be employed. Both, therefore, will be equally good measures of metabolism for the two individuals. The "discovery" that surface is no better as a measure of metabolism, than weight *as between individuals of nearly the same weight* could, therefore, have been made with paper and pencil.

[1] Abridged from an address delivered before the Yorkville Medical Society, New York City, March 21, 1921.

[2] Harris, J. A., and Benedict, F. G., "A Biometric Study of Basal Metabolism in Man," Carnegie Inst. of Washington, Publ. No. 279, Washington, 1919; Benedict, F. G., and Talbot, F. B., "Metabolism and Growth from Birth to Puberty," Carnegie Inst. of Washington, Publ. No. 302, Washington, 1921.

Contrast with this the relationship between individuals weighing 4 and 40 kilograms, or still better, an infant weighing $3\frac{1}{2}$ kilograms and a man weighing 70 kilograms. The weights are to each other as .05 to 1, and the surfaces as .135 to 1. In other words, the weight of the larger individual is twenty times that of the smaller, while the surface is a little over seven times that of the smaller. In this case the weight and surface can not possibly be of equal value as measures of the metabolism. One is nearly three times as good (or as bad) as the other. As a matter of fact it is now well known that surface is about two and one half times as good a measure as weight between two such individuals.

In the judgment of the writer it is incorrect to suppose that physiologists have believed the metabolism to be absolutely proportional to surface, regardless of circumstances. Rubner for the German literature and Richet for the French are responsible for the first demonstrations of the applicability of the law. Rubner worked with dogs of adult stature but widely different size, estimating their metabolism by the indirect method. Richet worked first with rabbits ranging from 2,000 to 3,500 grams in weight but he determined only the heat of radiation and conduction, neglecting, as nearly all subsequent French observers have done, the heat given off by evaporation. Naturally his quantities would be more nearly proportional to surface than the total. However, in the estimation of surfaces he says,

> If one supposes that animals of different size are like spheres of different volumes, then the respective volumes are related among themselves as the cubes of their radii; while the respective surfaces are related among themselves as the squares of their radii. These considerations apply to living animals, and, since their form is so irregular compared with that of a perfect sphere, one can only apply the geometrical facts to them approximately.[2]

Further in summing up the factors which determine heat production Richet notes that one of these is "the nature of the integument." In two important respects, therefore, Richet made saving clauses regarding the application of the law of surface, one concerning the measurement of surface and the other concerning the nature of the skin, meaning, of course, its conducting properties. Rubner in the beginning considered that he had demonstrated the law only for adult animals and later in applying it to children made this very emphatic reservation:

> The law of surface area holds under all physiological conditions of life, but for its proof it is a reasonable presumption that only organisms of similar physiological capacities, as regards nutrition, climatic influences, temperament,[3] and functional power, should be compared.[4]

Other students of metabolism have made similar reservations. Thus Schlossman says,

> The presumption is on the one hand that the environment is relatively normal, on the other that the child has a relatively normal surface, that is, a functioning and good conducting skin with the normal amount of subcutaneous fat.[5]

Otherwise, he thinks, the law could not be expected to apply.

One other point of some importance may be mentioned in this connection. There has been much discussion regarding the formula which should be used to express the body surface of infants. Rubner and Huebner modified the old formula of Meeh changing the constant from 12.3 to 11.9. Later Lissauer, from the measurements of a group of infants most of whom were distinctly undernourished, found the constant 10.3 to be more exact. Then came the formula of Howland and Dana of the $y = mx + b$ form, and still more recently the height-weight formula and the linear formula of DuBois, the latter similar to one previously devised by Roussy and first applied to infants

[2] Richet, Ch., "Recherches de Calorimetrie," *Arch. de Physiol. norm. et path.*, 1885, 3d ser., VI., 237.

[3] Misquoted as "temperature" by Harris and Benedict, loc. cit., p. 196.

[4] Rubner, M., "Ernährungsvorgänge beim Wachstum des Kindes," *Arch. f. Hyg.*, 1908, LXVI., 89.

[5] Schlossmann, A., "Atrophie und respiratorischer Stoffwechsel," *Zeitschr. f. Kinderheilk.*, Orig., 1912–13, V., 227.

by Variot and Lavialle. Benedict and Talbot have recently shown that the linear formula of DuBois gives results very nearly the same as the formula of Lissauer with a somewhat variable constant. Which of these formulæ is most nearly correct for body surface can only be determined by a statistical study of a large number of cases. However, if one of them is clearly superior to the others as a measure of heat production it should appear in the coefficients of correlation between heat production and surface as measured by the several formulæ. Harris and Benedict include in their statistical studies the basal metabolism of a series of 94 newborn infants, previously published by Benedict and Talbot. They did not, however, carry the analyses so far as to determine which formula gives the closer correlation with heat production. I have taken the trouble to work out the coefficients of variability and of correlation for the Boston series of 94 newborns using four different formulæ. They are given below.

TABLE II

Coefficients for the Minimal Metabolism of Newborn Infants (According to the data of Benedict and Talbot)

Coefficients of Variability	Coefficients of Correlation
$Vh = 15.37 \pm 0.79$	
$Vw = 14.68 \pm 0.72$	$Phw = 0.7530 \pm 0.0205$
$Vs_M = 9.92 \pm 0.48$	$Phs_M = 0.7672 \pm 0.0202$
$Vs_L = 10.08 \pm 0.49$	$Phs_L = 0.7762 \pm 0.0195$
$Vs_H = 10.25 \pm 0.50$	$Phs_H = 0.7677 \pm 0.0202$
$Vs_D = 8.84 \pm 0.43$	$Phs_D = 0.7682 \pm 0.0202$

V_h = Coefficient of variability of heat production, V_w of weight; etc. s_M = Surface by Meeh-Rubner formula ($s = 11.9 \sqrt[3]{(w)^2}$); s_L = Surface by Lissauer's formula, ($s = 10.3 \sqrt[3]{(w)^2}$); S_H = Surface by Howland and Dana formula ($y = mx + b$, where x is body weight, m represents a constant 0.483 and b represents 730 sq. cm.); S_D = Surface by weight-height formula of DuBois and DuBois ($s = \text{wt.}^{0.425} \times \text{ht.}^{0.725} \times 71.84$).

There are two surprises in this table: one, that heat production as determined by Benedict and Talbot is more variable than either body weight or body surface, no matter by which formula it is measured; and the other, that it makes very little difference which formula is used for body surface so far as correlation with heat production is concerned. The formula of Howland and Dana gives the most variable body surface; the height-weight formula of DuBois, which has never been confirmed for infants, gives the least variable. But the formula of Lissauer gives a body surface which parallels the metabolism *slightly* better than the others, the difference, however, being altogether negligible. Taking the entire group of newborns in this series we may conclude that the sleeping metabolism, which is practically the whole of metabolism in the newborn, is as well measured by one formula as another; also that surface by any formula is but slightly better than body weight as a measure.

We must distinguish clearly the arguments against the law of surface as of two classes: (1) on the basis of fact and (2) on the basis of explanation. The arguments against the law, so far as they rest upon facts, seem, as we have just seen, to have been misconceived. It never was supposed by its chief proponents that the law would apply to all physiological and pathological conditions but only to similar physiological (normal) conditions. Also, a very superficial understanding of the necessary mathematical relations shows that the law has natural limitations which must be recognized if one is to avoid compromising it with impossible conditions.

There is no doubt that Rubner, following Bergmann, first conceived of the law as causually related to Newton's law of cooling. This dependence as commonly accepted may be phrased in this way. Solid bodies when warmed lose heat in proportion to the difference between the temperature of the body and the temperature of the surrounding medium. Since this heat must all pass through the surface it follows, other things equal, that they will lose heat for any particular gradient of temperature in proportion to surface. As applied to the animal body it is observed that the body temperature is *nearly* constant. Hence, if heat is lost in proportion to surface, it must also be produced in proportion to surface. This implies a causal relationship between surface loss and interior

production of heat. It is this causal relationship to which Benedict and Talbot in their latest publication make objection. They say,

> As the result of the critique of the body surface law presented by Harris and Benedict, we believe that the accurate measurements of body surface made possible by DuBois may legitimately be used in a manner heretofore never practicable in metabolism experiments, provided that they are considered as physical measurements and with no erroneous conception as to the existence of a causal relationship between surface area and heat elimination.[6]

Nevertheless they compute many of their measurements by the Lissauer formula and find that many others as given by the DuBois linear measurements agree with the Lissauer formula provided a "constant" varying from 10.0 for infants up to 6 kgm. to 11.5 for youths between 25 and 40 kgm. is used. How the use of a physical measurement instead of a formula which agrees with the physical measurement improves matters it is difficult to see. The elaborate biometric analysis of Harris and Benedict has proved nothing more regarding the causal relationship than is proved by the simple mathematical analysis shown in Table I. Whatever the physical measurement of surface, if it can be expressed even approximately by a formula such as Lissauer's, it will follow that the ratio of body weights for certain ranges will be the same as the ratio of body surfaces *provided the weights are not far apart,* and for subjects of a continuous series in which weights differ by small increments it will follow that surface will be only a little, if any, better as a measure of metabolism than weight.

The question of causal relationship stands just where it always has stood. If the possession of a large surface in proportion to weight, as in a mouse, is accompanied by a vastly higher heat production per unit of weight as compared with a horse, but the heat production is found to be proportional to the surfaces of two such animals with approximately the same body temperature, it seems to follow that surface loss of heat is at least a more probable *cause* of heat production than body mass. The same is true as between a baby and a man. How else are such facts to be explained?

A word as to the teleological aspect of the case. Since heat production of animals seems to be proportional to surface area, it would seem to follow that heat is produced *in order to* replace that which is lost, or *to maintain* body temperature. This view some say, denotes an all too naïve conception of nature. Blood does not coagulate in order to prevent hemorrhage, but because certain chemical agents are present and certain properties. The fact that it does stop hemorrhage is quite incidental. It may have selective value, so that a species whose blood did not clot would have the worst of it in the struggle for existence, but it will never do to say that this chemical-physiological function originated for the purpose of preventing hemorrhage; for that would imply a mind at work in anticipation of the result. So also with heat production. These critics, of whom Kassowitz has been chief, prefer to account for heat production in a perfectly causal manner.

> Small animals maintain a higher rate of oxidation, it is true, than large ones, but this is not because they lose heat more rapidly in consequence of greater (relative) surface, but because their alternating movements (later phases caused reflexly by earlier phases) follow one another more rapidly on account of shorter nerve paths.[7]

Kassowitz indeed finds that the higher rate of oxidation in small, warm-blooded animals has even for them "dysteleological consequences; for because of the more extensive muscular contractions more food and reserve substances are placed in requisition and by this means the deposit of reserve fat in the whole body, and especially in the subcutaneous tissues, is made more difficult, so that the protection against cooling—which a thick layer of fat prevents—fails in part amongst the very animals which need it most."[8] Even

[6] Benedict and Talbot, *loc. cit.*, p. 159.

[7] Kassowitz, M., "Allgemeine Biologie," 1904, Chap. XXV., par. 40.

[8] Kassowitz, M., "Der grossere Stoffverbrauch der Kinder," *Zeitschr. f. Kinderheilk.*, 1913, VI., 247.

Kassowitz is obliged to admit, however, that "in warm-blooded animals which are in a position to maintain their own body temperature under the most diverse conditions, one can claim the appearance of some justification that their living parts produce heat in order to protect the body against loss by radiation, etc."[9]

Whether this is a real justification or only the appearance of one will not trouble the practical physiologist so long as the generalization that human beings of different size produce heat in proportion to surface rather than weight, and therefore, require food energy in this proportion, helps him to understand his feeding problems; and there is no doubt that the law of surface area has been immensely useful in this connection. It explains the much higher basal metabolism per unit of weight of the small individual in comparison with the large better than the so-called causal explanation cited by Kassowitz. It explains also much better the need for conservation of heat in the infant, and the role which subcutaneous fat plays in this connection.

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ON THE SIGNIFICNACE OF AN EXPERIMENTAL DIFFERENCE, WITH A PROBABILITY TABLE FOR LARGE DEVIATIONS

THE results of experiments from which scientific conclusions are drawn always constitute a sample, limited in number, of a potentially unlimited universe. The argument is always from the limited number to the infinite number, and assumes that the sample is representative of the universe. This is a priori not necessarily true, which is proven in the fact that two sets of measurements of supposedly the same quantity never agree in any absolute sense, that they may disagree widely, and that they therefore have to be qualified by a measure of their precision, which is derived from the magnitude of the mutual disagreement of the individual measurements of the same set.

This fact becomes of trying significance in many biological measurements. We may make two sets of measurements, A and B, under conditions alike except for one experimentally varied factor, and find that although their means show an apparently definite difference, many of the measurements A lie beyond the mean of B, and vice versa. It may be that a plot of the aggregate of the two distributions shows little or no bimodality corresponding to the difference in the respective conditions of A and B.

The usual mode of procedure in such a case is, first, to compute the measure of precision of the difference of the two means, according to the formula:

$$\sigma_\Delta = \sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}},$$

where Δ is the difference between the arithmetic means $(M_1 - M_2)$, σ_Δ its standard deviation, σ_1 and σ_2 are the standard deviations[1] of the two distributions A and B, respectively, and N_1 and N_2 are the respective numbers of measurements.

Then the probability, P, of a deviation lying within the limits $\pm\Delta$, in a normal distribution of standard deviation σ_Δ, is found from the table.[2] The complement of this, $1 - P$, is the probability of such a deviation lying outside the limits $\pm\Delta$.

The accompanying probability table was computed by the writer for deviations higher than those included within the range of most such tables extant, with a view to giving values of P much nearer to unity than usual. An approximate method of computation was used. While the computation of values of

$$\int_0^x e^{-x^2}\,dx$$

[9] Kassowitz, M., *ibid.*, p. 240.

[1] This assumes that

$$\sigma_1 = \sqrt{\frac{\Sigma\delta_1^2}{N_1 - 1}}.$$

Where N_1 is large the error due to the use of N_1 instead of $(N_1 - 1)$ tends to become negligible.

[2] Such as Table IV., pp. 119–125, Davenport, "Statistical Methods," third edition, New York; or Table 24 or Table 25, Smithsonian Physical Tables, Seventh Edition, Washington, 1920.

is laborious, excessively so where, as in the present case, many decimal places are required, it is possible to make a closely approximate integration of small segments of the function:

$$ydx = e^{-x^2}dx$$

such as

$$\int_{-z}^{z} e^{-(a+z)^2}dz,$$

where a is any abscissa and z is small.

Expanding the exponent, this becomes:

$$\int_{-z}^{z} e^{-a^2} \cdot e^{-2az} \cdot e^{-z^2},$$

which by putting

$$e^{-z^2} = 1 - z^2,$$

becomes

$$e^{-a^2}\int_{-z}^{z}(1-z^2)e^{-2az}$$

$$= e^{-a^2}\Big[e^{-2az}\Big(\frac{z^2-1}{2a} + \frac{z}{2a^2} + \frac{1}{4a^3}\Big) - e^{2az}\Big(\frac{z^2-1}{2a} - \frac{z}{2a^2} + \frac{1}{4a^3}\Big)\Big].$$

Reducing and substituting for z the value 1/10 gives:

$$\int_{-1/10}^{1/10} e^{-(a+z)^2} = \frac{e^{-a^2}}{4a^3}\Big[(e^{a/5} + e^{-a/5})a/5 + (e^{a/5} - e^{-a/5})(1.98a^2 - 1)\Big].$$

Thus, by assigning values to a, progressing by 0.2, the areas of the segments of the integral for the abscissal intervals $a \pm 1/10$ could be closely approximated and summated, the values in the table being finally:

$$\log\Big(2\int_x^{\infty} \frac{h}{\sqrt{\pi}} e^{-h^2x^2}dx\Big):$$

or log. $(1 - P)$, according to the usual symbology. It was found that it was only necessary in the extreme value given ($hx = 7.0$) to carry the computation a few steps farther, in order that the sum of the subsequent segments to infinity should be a vanishing quantity with respect to the degree of precision decided upon. The table is not to be looked upon as more than supplementary to the tables in general use, and upon examination, it will appear that the error introduced by assuming that $e^{-z^2} = 1 - z^2$ is negligible since, for $z = 1/10$ this error at its maximum is only as 0.99 — 0.99005 to 0.99, or 5 parts in 99,000 *with respect to* $1 - P$, and on the whole, even less than this; and it is the values of $1 - P$, smaller than those obtainable from the usual tables, in which we are here interested. The values of this table check with those in the usual tables, as far as the latter go, and also (in the extreme cases, especially where $hx = 5.0$, 5.5 and 6.0) with the values given in the original work of Burgess.[3]

EXPLANATION OF TABLE

Common logarithms of the values of the integral:

$$2\frac{h}{\sqrt{\pi}}\int_x^{\infty} e^{-h^2x^2}dx \; (= 1 - P)$$

for various values of hx.

$$hx = \frac{0.4769x}{E} = \frac{0.7071x}{\sigma},$$

where E is the probable error and σ the quadratic mean error.

Interpolations will be fairly accurate to the fourth place if proper account be taken of the second difference.

hx	log (1 — P)	hx	log (1 — P)
0.0	0.0000	3.5	3.8710-10
0.1	9.9482-10	3.6	3.5513
0.2	9.8906	3.7	3.2231
0.3	9.8270	3.8	2.8865
0.4	9.7571	3.9	2.5415
0.5	9.6808	4.0	2.1880
0.6	9.5978	4.1	1.8261
0.7	9.5081	4.2	1.4557
0.8	9.4115	4.3	1.0768
0.9	9.3077	4.4	0.6895
1.0	9.1967	4.5	0.2936-10
1.1	9.0784	4.6	9.8893-20
1.2	8.9527	4.7	9.4764
1.3	8.8195	4.8	9.0551
1.4	8.6787	4.9	8.6252
1.5	8.5301	5.0	8.1868
1.6	8.3739	5.1	7.7399

[3] Burgess, *Trans. Roy. Soc. Edinb.*, XXXIX., p. 257 ff. "On the Definite Integral $(2/\pi)\int_0^t e^{-t^2}dt$ with Extended Tables of Values."

1.7....8.2098	5.2....7.2844
1.8....8.0378	5.3....6.8204
1.9....7.8579	5.4....6.3479
2.0....7.6700	5.5....5.8668
2.1....7.4741	5.6....5.3771
2.2....7.2702	5.7....4.8789
2.3....7.0581	5.8....4.3721
2.4....6.8379	5.9....3.8567
2.5....6.6095	6.0....3.3328
2.6....6.3730	6.1....2.8003
2.7....6.1282	6.2....2.2593
2.8....5.8751	6.3....1.7096
2.9....5.6138	6.4....1.1514
3.0....5.3442	6.5....0.5846
3.1....5.0663	6.6....0.0092–20
3.2....4.7800	6.7....9.4252–30
3.3....4.4854	6.8....8.8326
3.4....4.1824	6.9....8.2314
3.5....3.8710–10	7.0....7.6216–30

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LABORATORY OF PURE SCIENCE,
NELA RESEARCH LABORATORIES
May, 1921

POLARIZATION OF SOUND

THE term polarization, applied to a wave motion, is generally associated only with transverse waves, more especially with light-waves, as referring to a state in which certain qualities are different in certain directions at right angles to one another and to the direction of propagation. By its origin, however, the term may be used with the same justification for longitudinal waves exhibiting qualities that are different in different directions, irrespective of the nature of such qualities and the relation of the various directions to each other.

It is thus proper to speak of a polarization of sound when conditions prevail under which a quality like its pitch is of opposite character to opposite sides of a fixed plane or axis.

Such conditions may be brought about by putting the source, which for the sake of simplicity is supposed to produce a sustained sound of uniform pitch, through certain movements. It is well known that when such a source is in motion the pitch of the sound emitted into space will be a function both of the direction of the movement and its speed.

This is due to the relative displacement of the individual wave rings by the motion, and is readily observed by anyone standing close to a railroad track while a locomotive blowing its whistle is passing. At the instant of passage there is a sudden fall in the pitch of the blast, the fall being approximately proportional to the speed of the locomotive.

The pitch observed at any point may be expressed by the formula:

$$p = q\frac{v}{v-u},$$

p denoting the pitch observed, q the pitch produced, v the velocity of sound, and u the speed component of the movement in the direction of the observer, with due consideration of its sign.

If the source, instead of being moved at uniform speed in one direction, is made to perform a harmonic oscillatory movement at right angles to a plane P, and symmetrical to it, then the resulting sound will be of uniform pitch only at points located in this plane, assuming the extent of the movement to be small as compared with the distance to the point of observation. To either side of the plane the pitch will be undulating, the undulations reaching their maximum amplitude at points directly in line with the movement.

While the undulations will be of the same amplitude at any two points symmetrically located with respect to the plane, they will be opposite in phase and, therefore, of opposite character. Accordingly, if the source is made to emit sound while to one side of the plane only, *i.e.*, during alternate half oscillations, then, by the above formula, the resulting sounds will be of descending pitch to that side of the plane, while to the opposite side of it the same sounds will be of ascending pitch. The sound may thus be said to have been polarized with respect to the plane P.

If the oscillatory movement of the source is substituted by a rotation at uniform speed about an axis A, results of a similar nature are obtained. In this instance, however, the resulting sound will be of uniform pitch only

at points directly in line with the axis, while aside of it the pitch will be undulating. The undulations will reach their maximum amplitude at points located in the plane of rotation, being of opposite character at any two points symmetrically located with respect to the axis.

In the terminology of optics, the sound may be said, in the latter case, to have been circularly polarized with respect to the axis A.

Polarized sound-waves may be of value in acoustic research, for investigations involving the direction of sound. They are also applicable to practical purposes, like fog signalling. The signals may be polarized in such a way as to enable a pilot to determine with ease and certainty, *and by the unaided ear*, the direction from which they are coming. A device for this purpose has already been constructed by the writer and has successfully stood the test, it being possible to locate the source within a "point" of the compass.

ANDERS BULL

CHICAGO, ILL.,
June 27, 1921

THE AMERICAN CHEMICAL SOCIETY

(*Continued*)

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Charles E. Caspari, *chairman*.
Edgar B. Carter, *secretary*.

N-derivatives of arsphenamine. I. Introduction of fatty acids: GEORGE W. RAIZISS and JOSEPH L. GAVRON. *II. Aldehyde addition products:* GEORGE W. RAIZISS and ABRAHAM C. BLATT. The authors introduced various atomic groupings in arsphenamine and studied the biological properties of the resulting compounds. They observed that the amino groups have a controlling influence upon the toxicity of the drug. Five derivatives of arsphenamine each containing a fatty acid substituent in both amino groups have been prepared. On the whole they are less toxic than the parent substance. Addition products of arsphenamine and various aldehydes, in which two molecules of the aldehyde are combined with one of arsphenamine, have also been prepared. Some of these have characteristic colors and may prove to serve as a means of identification. The biological study of these compounds is still in progress. One has been found less toxic than arsphenamine and also exhibits marked trypanocidal properties.

Some recent observations on protoplasmic stimulus: G. H. A. CLOWES. It has long been known that the sperm of sea urchins and other marine forms may be stimulated to excessive activity and their fertilization capacity promoted by treatment with extracts and secretions of eggs of the same species. This substance has now been proved to be a volatile, readily oxidized, non-specific, organo substance, resembling the lower alcohols or mercaptans. Similar sperm stimulating and fertilization promoting results may be obtained by utilizing a large variety of organo substances at dilutions of one in a hundred million or more.

Significance of residue determination as a test for the purity in drugs and chemicals: H. V. FARR. Salts of potassium and sodium are apparently more volatile in the presence of vapors of other metals, making their determination by ignition difficult in such compounds as mercury salts. The results seems to indicate widely different interpretations of the ignition test by different chemists. A much more accurate definition of the U. S. P. requirement is essential.

A new use for edible oils in surgery: CHARLES BASKERVILLE. Numerous efforts have been made to introduce gaseous anesthetics, as ether vapor, into the lower bowel until Dr. J. T. Gwathmey, of New York, conceived the idea of utilizing the solubility of ether in oil and administering the mixture as an enema. Fundamental factors were established by the investigations of the author before the proposal was tried with human beings. He determined the rates of evaporation of ether from various oils, mainly vegetable, although Russian mineral oil was also used. It was conclusively proven that ether evaporates from its solution in or of various oils suitable for internal use at a definite rate at the temperature of the human body. Nearly 30,000 operations, every one successful from the patient's point of view, have been performed by using this method. Not a single untoward circumstance has been reported. Vomiting, post-anesthesia nausea and many other uncomfortable accompaniments have been reduced to a minimum. Gwathmey also introduced the oral administration of the oil-ether mixture to produce analgesia during the dressing of wounds. Some surgeons have utilized the method in civilian practise in dressings after operations.

Further study of saligenin and allied compounds:

ARTHUR D. HIRSCHFELDER. Saligenin in two to four per cent. solution is a practical local anesthetic not only for minor but also for major surgical operations such as thyroidectomies and laparotomies, and for caudal anesthesia; in 4 to 8 per cent. solution it is particularly useful in anesthesia of the male and female urethra for cystoscopy. Quigley and Hirschfelder have shown in a series of phenyl carbinols that substitution for one of the inactive hydrogens of the carbinols lessens the anesthetic action and substitution of both causes it to be lost. Ethyl, propyl, *n*-butyl, iso amyl and benzyl ethers of saligenin were prepared from potassium saligenate and the corresponding halide. They all numb the tongue like cocaine, the butyl ether most, but all also produce a stinging sensation as well. Emulsions made with acacia lower the blood pressure on intravenous in rabbits, the benzyl ether producing the most lasting effects. The mono acetic, di benzoic and mono benzoic esters of saligenin have been prepared, as well as the acetate and salicylate of bromsaligenin.

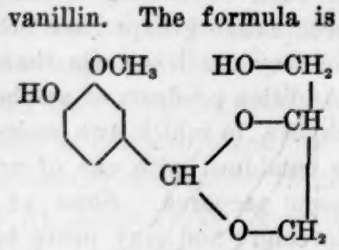
Molecular magnitude and physiological action: OLIVER KAMM. Molecular volume data were utilized to predict the relative acute toxicities of monohydroxy alcohols belonging to several different homologous series. Benzyl alcohol and its homologues were found to agree with predicted values.

Preparation and hydrolysis of benzyl esters: E. H. VOLWILER. Benzyl benzoate as an antispasmodic has come into increasingly general use since it was first suggested by Macht. With the purpose of finding the benzyl esters best adapted as antispasmodics, a number of other benzyl esters, both new and old, were prepared and their hydrolysis rates determined. The rates of hydrolysis of these benzyl esters increase in the following order: salicylate, benzoate, stearate, cinnamate, acetate, succinate, and fumarate. Benzyl acetylsalicylate, a new compound melting at 26°, was prepared; its rate of hydrolysis is very rapid, due to the presence of the acetyl group. It is therapeutically the most active of all the benzyl esters investigated.

Arsphenamine: Some factors which influence its colloidal properties: A. E. SHERNDAL. When the pentavalent aryl arsenic acids are reduced to the trivalent arseno compounds, their well marked crystalloidal characteristics are suddenly replaced by decidedly colloidal tendencies. This may be caused by the formation of large complex molecular aggregates. Arsphenamine in dry form shows marked colloidal properties, which vary in degree with the method of preparation. Precipitation from ionized solutions tends to increase these colloidal tendencies, while anhydrous non-electrolytes tend to reduce them to a minimum, as shown by experiment. These variable colloidal characteristics are paralleled by differences in the disperse state of acid and alkaline arsphenamine solutions, and may account for hitherto unexplained toxic and biologic phenomena exhibited by such solutions.

Laboratory tests vs. clinical results: ROBERT P. FISCHELIS. A discussion of the need for clinical evidence of the value of medicinal products and how such evidence may be obtained. The author included a discussion of the necessity for drawing proper conclusions from laboratory tests, as compared with clinical results.

Vanillin glyceride: FRANCIS D. DODGE. A crystalline deposit which had formed after a time in a flavoring mixture composed essentially of vanillin, glycerin and alcohol was found to be a compound of vanillin and glycerin, apparently analogous to the benzol-glyceride described by Fischer. The compound is obtained more readily with acid catalysts (hydrochloric or sulfuric acids) and when purified melts at 159°. It is very slightly soluble in water or ether, more readily in alcohol, and may be recrystallized from hot alcohol. It is soluble in aqueous potassium hydroxide, and is reprecipitated by acids. The compound is hydrolyzed by hot water, yielding vanillin and glycerin in equivalent amounts. It is also very quickly hydrolyzed in acid solutions, so that the preparation requires much care. For purification, the crude crystals are dissolved in the calculated amount of 0.5*N* KOH, and reprecipitated by somewhat less than the theoretical amount of acid. The compound thus obtained forms thin plates, which are stable in dry air. Under the microscope, the crystals show, in convergent polarized light, an orthorhombic interference figure, and are thus easily distinguished from the monoclinic needles of vanillin. The formula is probably:



CHARLES L. PARSONS,
Secretary